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31 March 1975

Mr. Dennis Stillings, Curator
THE MEDTRONIC ARCHIVE
3055 Old Highway Eight
Minneapolis, Minnesota
USA 55418

Dear Mr. Stillings:

At last! Here is the completed biofeedback music instrument. I have titled it "Portable Gold and Philosophers' Stones II" for Medtronic Archive. I hope you will enjoy it. I have put a lot of R&D into it. What follows are some instructions for its use. Please refer to diagram "A" of the enclosed drawing series. It is a front panel diagram and I will use it to explain the operation of the controls.

No. 1: These are the left and right channel monitor speaker and external, audio output, interface jack, level controls. It is desirable to connect the instrument to a hi-fi sound system whenever possible. This may be done by connecting the output jacks to any high level input on a good stereo system, such as AUX, TUNER, TAPE PLAYBACK, etc. inputs. The two master level controls will govern the levels of both the external and the internal monitor systems. The levels should be well balanced so that individuals can identify their own feedback signal.

No. 2: This is the main power switch. Next to it is mounted a fuse holder which should always contain a 1 amp fuse, such as BUSS AGC 1. NEVER PUT A LARGER FUSE IN THIS HOLDER! If something has gone wrong with the instrument, (it has been thoroughly tested and "burned in" so we hope this will not happen), a larger fuse will only increase the chances of blowing something out. Notice that the power cord has a three prong plug for standard wall outlets. NEVER USE THIS INSTRUMENT WITH A TWO PRONG ADAPTER! All equipment which involves biological interface is protected against any potential shock hazards, however, this protection depends on proper power supply grounding. When measuring signals that are as small as brain waves, this grounding is also necessary to avoid AC line interference.

No. 3: These are the level controls for mixing individual feedback signals. Feedback signals for individuals 1 and 2

(pink and orange switch caps), will always appear on the left output channel and signals for individuals 3 and 4, (blue and yellow switch caps), will always appear on the right output channel. These level controls are useful for identifying individual feedback signals which would be hard to follow otherwise. It is necessary for participants to give extreme concentration to their feedback sound in order to be able to follow all of its subtleties. This is difficult at first but certainly can be learned.

No. 4: An output signal can be produced for each individual that is controlled in one of three ways. These switches select the control mode for the feedback signal. The first mode, upper switch position, produces a sweeping, warbling sound that follows the waveform of the brain wave or other biological signal exactly. In the case of brain signals, this will be a very fast warble and is useful for following individual waveforms. It is more useful in the case of other signals, such as heart beat, EKG, signals. A sweeping sound will be produced that follows the heart beat pattern. The second control mode, middle switch position, produces a sound that moves up and down the musical harmonic series as the amplitude of the brain wave signal increases and decreases. This will allow an individual to follow increases and decreases in Alpha, Beta, or Theta activity. The higher the sound goes the larger the amplitude of the associated brain wave activity. This is probably the most musically useful control mode and the best one for individuals to learn with. A musical interplay of natural harmonics will result if four persons learn to control their brain signals through this mode. The third control mode, lower switch position, is the most difficult to learn to control and should be tried by individuals, only after they have had practice with control mode two. In this mode, a brain wave signal, Alpha burst, for example, of sufficient size will trigger an automatic, preprogrammed sweep up and down the harmonic series. The size of the sweep will be determined by the size and length of the Alpha burst. An interesting conversation between players can follow if they learn to selectively turn on and off large bursts of Alpha. The threshold of brain wave amplitude required to trigger this sweeping sound is controlled by the input amplifier gain controls, to be described later.

No. 5: The brain wave envelope signals that are used to control the sound in control mode two are available at these output jacks. The envelope signal is a slowly varying voltage which is proportional to the amplitude of the brain wave signal being monitored. These signals can be used to interface the instrument with electronic music or video synthesizers or they can be monitored on an oscilloscope to view changes in the levels of the selected brain wave. Another interesting application of these signals is to be found in the "Alpha-Etch-A-Sketch" idea. In this case, two envelope signals are connected to an X-Y storage oscilloscope, one signal to the X axis and one to the Y axis. Line drawings can then be made by the participants, providing another form of feedback.

No. 6: These switches select the brain wave frequency bands of Beta, 13 - about 20 Hz, Alpha, 8 - 13 Hz, or Theta, 4 - 8 Hz, for each individual being monitored. The filtered brain wave signal is also available on an associated output jack for viewing on an oscilloscope or printing on a chart recorder. These signals may also be interfaced with other types of audio or video synthesizers.

No. 7: These are the electrode input jacks. They must be connected as follows. The black jack must always be connected to a grounding electrode. Ear clip electrodes are provided for this purpose. The yellow and brown jacks are connected to the inputs of a differential, biological signal, preamplifier. This amplifier amplifies the differences in voltage measured between two points on the skin. In the case of brain waves, one of these differential inputs would be connected to a neutral point, such as the other ear lobe, and the active point to be monitored. Alpha brain waves can be recorded from many places on the scalp, however, the strongest signals usually occur over the occipital lobe, the back of the head. A good location for the active electrode is in the center of the back of the head, about one inch above theinion, or bottom of the skull bone in the back. Always use ample electrode paste, applied to the electrode itself, and make sure good contact with the skin is made. It is wise to clean away skin oils with a bit of alcohol. **GOOD ELECTRODE CONTACT IS ESSENTIAL FOR THE OPERATION OF THE INSTRUMENT!** It is also wise to measure the resistance between the two active electrodes after they have been applied to the skin with an ohm meter. The resistance should be less than 100,000 ohms for good contact. For monitoring heart beat, the grounding electrode should still be applied to the ear lobe but the two active electrodes should be attached to either side of the left lung area. Small bits of adhesive tape can be used for this purpose.

No. 8: These switches select high or low gain for the input amplifiers. The high position should be used for monitoring brain wave signals and the low position for other signals, such as heart beat.

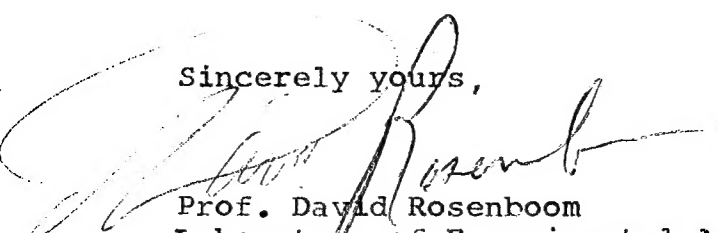
No. 9: These knobs provide a variable gain for the input amplifiers of 0 to 100,000X. This knob is only operative if the gain switch is in the high position. Since this knob controls how much the brain wave signal is amplified, it will also control the operation of the audio system. It will influence the range of movement of the sound and will determine the threshold for triggering the sound sweeps in control mode three. Generally speaking, this knob should always be kept as low as possible while still getting good operation of the sound generating system. You will find that as the participants learn how to produce stronger brainwave signals this knob can and should be lowered. This allows the individual to progress as well by requiring larger and larger brain signals to trigger the sound.

I hope that these instructions, along with my book, Biofeedback and the Arts, will help get you started.

Please let me know if you need any other information. The system has undergone many tests and should be quite reliable. Lastly, I would just comment that learning to sensitively operate the gain control knobs is a key to getting the most out of this instrument.

Enjoy it.

Sincerely yours,



Prof. David Rosenboom
Laboratory of Experimental Aesthetics